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Long-term Prognosis in Cardiac Surgery of Pure Pulmonary Stenosis and Ventricular Septal Defect

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I. PURE PULMONARY STENOSIS

10 YEARS HAVE elapsed since cardiac operations have been performed in this country. During this period total number of 2500 cases of cardiac operations have been performed at Tokyo Women's Medical College. Among these cases, 74 cases of pure pulmonary stenosis has been operated on until January 1961. The investigation was done in 63 cases of pure pulmonary stenosis excluding death due to the operation.

The longest survival after the operation is 9 and half years. Methods of operation have changed from early Brock's operation to valvulotomy under direct vision and with extracorporeal circulation (Table I). These cases are classified hemodynamically as mild with right ventricular pressure less than 50 mmHg,

moderate with the pressure less than 100mmHg and severe with the pressure more than 100 mmHg. Post-operative hemodynamic changes were evaluated in 7 cases and showed lowering of right ventricular pressure and elevation of pulmonary artery pressure in each case. In mild and moderate cases the right ventricular pressure returns to near normal level in relatively early period after the operation. Contrary to this, relatively longer time is required to return to near normal level.

Phonocardiograms of 27 cases were evaluated before and after the operation. Only systolic murmur was seen at pulmonary area in 6 cases, systolic and diastolic murmurs were seen in 21 cases. The more severe the case, the more the peak of systolic murmur locates near the second heart sound and the interval of split second heart sound prolongs. In 17 cases with clearly demonstrated systolic murmur post-operatively, the interval between the first heart sound and the peak of systolic murmur become short. However in severe cases, the peak locates after the mid-systole even after the operation, as shown in Fig. 1. However the peak moves toward the first heart sound gradually with the follow-up of the course. As shown in Fig. 2, the interval of split second heart sound becomes short except one case of prolonged interval. In this case the complete right bundle branch block was created after the operation. With the uneventful course, the shortening of the interval of split second sound is observed. Diastolic murmur is demonstrated in 78% of cases after

TABLE I TOTAL NUMBER OF P.S. OPERATED ON UNTIL 1960

Cases year	Operated cases	Survived cases	Death number	The method of operation in that year
1952	2	2	0	BROCK's Op.
1953	3	3	0	BROCK's Op.
1954	7	7	0	BROCK's Op.
1955	6	6	0	Commissurotomy with Hypothermia
1956	8	5	3	Direct Visual Operation with Artificial Heart-Lung Apparatus
1957	9	7	2	
1958	8	6	2	
1959	16	12	4	
1960	15	15	0	
Total	74	63	11 (14.9%)

Fig. 1. Changes of $\frac{1st\ sound - Mp}{1st\ sound - A_2}$ in P.S. after the operation.

Fig. 2. Changes of $A_2 - P_2$ Interval in P.S. after the operation.

the operation and this will be ascribed to regurgitation of valvulotomized valve. The murmur is observed even in case with accurate commissurotomy.

The evaluation of electrocardiograms were done in 22 cases, follow-up more than one year, 14 cases showed right axis deviation, which tended to become normal post-operatively. 3 cases in moderate and severe cases still right axis deviation. Cases with P-dextrocardiale showed flattening of P-wave after the operation. Incomplete right bundle branch block was created in 4 cases after the operation and incomplete right bundle branch block changed to complete right bundle branch block was seen 2 cases, and incomplete right bundle branch block disappeared in 2 cases post-operatively (Fig. 3). There was no obvious relation between the incidence of bundle branch block and the method of operation.

Fig. 3. Changes of QRS in each severity in P.S. after the operation.

The height of R in V_1 shows some correlation to the right ventricular pressure before the operation, but the height of R in V_1 decreases in each case after the operation, as shown in Fig. 4. However in some cases with

Fig. 4. Changes of RV_1 in each severity of P.S. after the operation.

moderate and severe groups, the height of R in V_1 still remains high. In a moderate case the height of R in V_1 was decreased but increased again two years after the operation. However in this case S in V_1 increased in its depth and R/S decreases in a year after the operation. There was no change of ST in cases with more than one year after the operation. T waves were inverted through V_5 or V_6 in severe cases before the operation, but T waves become gradually upright and near normal in left precordial leads after the operation.

There was no case of marked reduction in size of the heart by x-ray. Lung-fields show somewhat increased pulmonary flow in each case. Enlarged liver was observed in a

case with simultaneous closure of atrial septal defect but it was disappeared one year after the operation.

Anginal pain and tightness of chest which appeared in severe cases before the operation disappeared and increased in functional capacity after the operation. Growth in a year after the operation was examined and the height was somewhat inferior to the standard growth in a year published in 1960, as shown in Fig. 5. Increase in weight was compared with Kaup's index, as shown in Fig. 6, and showed to become near the standard value in young age.

Fig. 5. The increase in height in a year in P.S. after the operation.

Fig. 6. Changes of kaup index in P.S. before and after the operation.

When the time to attend the school and subjective symptoms after the operation were evaluated by questionnaire, 80% in a year and all cases in two years attended the school. 90% of cases with than two years after the operation showed normal activity in the school without any handicap in gymnastics. 80% returned to their previous professions in two years after the operation. Efficacy of their ability in work has been improved in 30% and remained same in 40%.

Changes of character before and after the operation was examined by questionnaire to the family. No changes was seen in 65% and improvement was seen in 30%. One case changed to diffident character.

As the summary, improvement was seen in all cases successfully operated on in this disease. There was no obvious changes of surgical outcome on the method of operation if the commissurotomy is done enough so as to be able to pass finger. However in cases

Fig. 7. The classification of severity in V.S.D.

Severity I: pulmonary systolic pressure, less than 40 mmHg with left to right shunt.

Severity II: pulmonary systolic pressure 41-80 mmHg with left to right shunt.

Severity III: pulmonary systolic pressure more than 81 mmHg with left to right shunt.

Severity IV: pulmonary systolic pressure more than 81 mmHg with right to left shunt.

Fig. 8. The increase in height during a year after the operation of V.S.D.

Fig. 9. Changes of Kaup index in V.S.D. before and after the operation.

in which commissure is incised accurately under the direct vision operation, murmurs were almost inaudible and the prognosis seems to be excellent. There is no hazard clinically in pulmonary regurgitation. In severe cases it takes 3 to 5 years or more to return to normal hemodynamically and mortality due to operation is high, so that the early operation is recommended.

II. VENTRICULAR SEPTAL DEFECT

183 cases of ventricular septal defect have

been operated on from March 1955 to January 1961. Meanwhile operated cases have been increasing and mortality due to operation has been decreasing year by year. V.S.D. is classified by severity as four groups, as shown in Fig. 7. When the risk is compared in each group, mortality in II and III groups has been decreased (Table II), when compared with figures published in 1959. Cases in IV group have not been operated on at present.

TABLE II MORTALITY RATE IN EACH SEVERITY IN V.S.D.

Severity	Case	Mortality Rate by operation
I	41	7 %
II	18	39 %
III	6	83 %
IV	3	100 %
(1955-1959)		
I	66	9 %
II	30	27 %
III	9	56 %
IV	5	100 %
(1955-1961)		

Lowest mortality of 5% was obtained in cases operated on without cardiac catheterization and recent mortality rate is 8.4% including severe cases which operated during 1959 to 1961.

This investigation was done in 139 cases successfully operated. Post-operative hemodynamics were examined in severe case and one case developed congestive heart failure 4 months after the operation in III group and remaining cases showed normal pulmonary artery pressure. These cases showed no shunt after the operation, but pulmonary systolic murmur was demonstrated in phonocardiogram. In one case in II group, the defect was closed through right atrium with incision of tricuspid valve and again the suture was done on the incised tricuspid valve. In this case the tricuspid regurgitation was demonstrated by post-operative cardiac catheterization. One year after the operation the course of the patient has been uneventful without hepatomegaly. After the closure of the defect, the right ventricular pressure returns to normal in short period (Table III). After the operation, the disappearance of the murmur is imagined, however, actually the systolic murmur is audible

TABLE III HEMODYNAMIC CHANGES OF SEVERE CASES IN V.S.D. AFTER THE OPERATION

Severity	Case No.		Pulmonary Artery Pressure mmHg	Systemic Pressure mmHg	P/S Pressure Ratio %	Shunt Ratio %	Direction of Shunt	Course
II	2757	Before	48/16	104/50	46	37	L-R	Good
		2 months later	35/2	112/60	31	—	—	
II	3027	Before	61/25	90/63	67	58	L-R	Good
		3 months later	32/16	106/60	30	—	—	
II	3037	Before	72/10	118/90	61	59	L-R	Good
		2 months later	28/0	110/80	25	—	—	
III	2891	Before	85/5	100/85	85	56	L-R	Good
		8 months later	26/0	116/60	22	—	—	
III	2901	Before	90/25	110/60	81	23	L-R	Good
		12 months later	44/10	114/80	39	—	—	
III	1634	Before	100/60	116/54	94	14	L-R	Congestive Failure
		4 months later	50/20	96/42	52	37	L-R	

in fairly large number of cases. Disappearance of murmur was observed in only 56 % of cases and soft systolic murmur was audible in 30 %. Systolic murmur of grade III or more, based upon Levine's classification, were audible in 8.5 %. When compared with phonocardiographic findings, the murmur was not demonstrated in 21 %, faint systolic ejection murmur in 38 % and systolic ejection murmur was seen in 30 %. There are problems on intensive ejection murmur, regurgitation murmur and diastolic murmur. Among these intensive ejection murmurs, the shunt was not demonstrated by cardiac catheterization in some cases. In two cases with regurgitation murmur, the mild tricuspid regurgitation was seen, and in two of four cases with diastolic murmur, the murmur was ascribed to pulmonary regurgitation due to the operation of the defect located beneath the pulmonary valve. Post-operative splitting of second heart sound is not a good index to estimate the result of operation because bundle branch block is created in many cases. The relation of patch applied to the defect and the incidence of murmur is not clearly demonstrated.

On electrocardiograms, first or second atrioventricular block was demonstrated in some case immediately after the operation. In one case long-continued second atrioventricular block was seen and no case of complete atrioventricular block was seen. The newly created right bundle branch block and incomplete right bundle branch block changed to complete were seen in 49 % totally, and with preoperatively

TABLE IV CHANGES OF R.B.B.B. IN V.S.D. AFTER THE OPERATION (77 CASES)

(-) → irbbb	22 cases	29 %
irbbb → irbbb	22 cases	29 %
(-) → (-)	14 cases	18 %
(-) → crbbb	5 cases	6 %
irbbb → crbbb	11 cases	14 %
irbbb → (-)	2 cases	2.5 %
(-) → irbbb → (-)	1 case	1.5 %

existed right bundle branch block, the right b.b.b. was seen in 78 % totally (Table IV). No obvious relation was found between the location of defect and bundle branch block. There was no constant relation between R in V₁ and S in V₅ because of the incidence of post-operative right bundle branch block. Post-operative high R' showed no changes with the elapse of time, and this is not ascribed to the right ventricular overloading. R in V₅ and S in V₁ decreases with the lapse of time, in cases with decreased R in V₅ less than 3 mV and increased again, and in cases with increased R more than 3 mV and increased depth of S in V₁ showed re-opening of the defect or associated aortic regurgitation.

The heart size does not change remarkably in X-ray. In cases with preoperative marked congestion, the intensity of congestion decreases two months after the operation. In 86 cases examined in this department, the intensity of congestion was decreased in 50 %, and no obvious changes were seen in 45 %. Increased congestion after the operation or increased congestion after the decrease temporarily is suggestive of re-opening of defect or aortic regurgitation.

Post-operative growth was examined as

in case of pulmonary stenosis. Growth in this disease is better than that of pulmonary stenosis. As shown in Fig. 8, the height exceeds that of standard growth in a year at age 6 to 15. The weight, as shown in Fig. 9, also exceeds the standard curve in many cases. Post-operative attendance to school was examined, and 88% of cases attended the school without subjective symptoms in a year after the operation and most of patients attended the school with normal activity in gymnastics in two years. 58% of cases returned to previous professions in a year and 84% in two years after the operation without subjective symptoms. Improvement in efficacy in working is seen in 24%, no obvious changes in 50% and lowering in only 3%.

As for character, no changes of character were seen in 74%, changes to cheerful character in 20% and diffident in 3%. Therefore no effect on intelligence or character by hypothermia or extracorporeal circulation was observed. Rather improvement by having confidence on their bodies is remarkable.

As the summary, prognosis after the operation is determined by the complete closure of the defect. Even in cases with incomplete closure or application of patch with holes, some degree of improvement can be obtained after the operation. Including these cases, improvement was seen in 95% but re-opening of the defect makes the prognosis worse. In re-opening case, re-operation is attempted at present to close the re-opening under direct vision and the result is good. If possible, not to re-open the closure of the defect. For this purpose we attempt after the closure of defect by continuous suture, string is placed

on it as U shape and the end is fixed by piece of artificial vessel. Recently complication of aortic regurgitation has not observed. From the point of risk, the risk is high in operation in severe cases. On the point of recovery, we have only a few severe cases such as equilibrium of systemic and pulmonary artery pressure, so that this problem must be solved in future. Otherwise, if the closure is complete, the hemodynamic improvement is seen and efficacy in working is improved regardless of severity. However with high risk in operation and without postoperative reduction of heart size in X-ray in severe cases, the early operation is recommended if the operation is indicated.

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